PUTTING RESEARCH TO WORK BRIEF

Protective Coatings Prevent Bridge Beam End Corrosion

Designed to last 50 to 100 years, Wisconsin's bridges prove expensive to replace. A recently built 110-foot-long, two-lane bridge on US 151 in Fond du Lac County was projected to cost $11 million. With replacement costs so high, keeping the state's inventory of 13,000 bridges in good condition is critical.

What's the Problem?

Increased traffic, deicing salts, and ineffective preventive maintenance programs contribute to bridge deterioration. Some structures show serious distress at ages well short of 50 years.

Corrosion, caused mainly by the use of deicing salts in winter maintenance, proves to be the biggest problem. Beam ends bear the brunt of the damage, as water leaks through faulty expansion joints, promoting corrosion, cracking and spalling (chipping and flaking).

The conventional repair technique, patching the damaged areas, rarely works well for long. Poor bonds between old and new sections trigger spalling, and contaminants from old sections migrate into new. Fiber-reinforced polymers, shown to be very effective at mitigating and preventing corrosion damage in columns, had yet to be studied on beam ends.

Research Objectives

A research team from the University of Wisconsin–Milwaukee studied repair and rehabilitation techniques for reinforced and prestressed concrete bridges, focusing on corrosion of prestressed concrete beam ends. Their objectives were to collect and synthesize information on rehabilitation methods; evaluate the effectiveness of preventive and corrective methods of addressing distress; and begin developing new software to help engineers assess bridge deterioration and identify maintenance options.

Methodology

Investigators' tasks included:

• **Literature search.** Researchers reviewed literature related to rehabilitation of concrete bridges, with a focus on structures in northern climates.

• **Laboratory work.** Investigators tested the most promising coatings on the ends of five new 8-foot-long prestressed concrete I-beams. All surfaces of the 2 feet nearest the beams' ends were coated; some ends were left untreated for comparison.

  • Four treatments were tested: a carbon fiber-reinforced polymer wrap; a polymer resin coating without fiber; an epoxy coating; and a common solvent-based sealer. Researchers also tested patching with a widely used cement-based mortar.

  • Beams were subjected to wet/dry cycles of salt-water spray for six months. Cathodes carrying electric current were embedded in the beams to accelerate corrosion.

  • After six months, researchers coated and patched some of the untreated ends, then applied the same accelerated corrosion method to all beams for 12 more months.

• **Analysis.** Researchers evaluated each treatment based on the extent of cracking observed, measured chloride penetration, and the extent of corrosion observed during dissection.

• **Software development.** Investigators began developing a software program designed specifically for concrete bridge damage assessment and treatment. This software aims to improve upon the more generalized HWYCON program, which assists in diagnosing distress in bridges, pavements, construction and materials.

Investigator

"We can mitigate corrosion with relatively simple methods, especially if it's done during construction. We were surprised at the level of protection that could be afforded."

–Habib Tabatabai
University of Wisconsin–Milwaukee
ht@uwm.edu

After six months of laboratory exposure to salt spray cycling, an uncoated concrete beam (left) suffered significant end corrosion. An adjacent beam, this one coated with a polymer resin, showed little damage.

Results

Researchers found the most effective method of preventing beam end corrosion was to apply a polymer resin coating to beam ends before installing them in the field. The FRP wrap was about equally effective, but more costly and difficult to install than the polymer resin coating. Epoxy coating was the next best solution, followed by the solvent-based sealer.

For repair of existing bridges, researchers recommend applying the protective coatings as soon as possible to bridges that do not yet show significant corrosion damage. In cases where corrosion is advanced, conventional patching is not likely to be a durable repair method. Adding a protective coating to a patch repair may provide a more effective repair.

Researchers developed an initial version of the Concrete Bridge Assessment and Rehabilitation (ConBAR) program. Through a user-friendly interface, an engineer or inspector answers an extensive series of questions about a bridge's condition and history. Based on established expertise, the software then provides suggestions for preventive maintenance, repair and rehabilitation.

In addition, following the literature search, researchers built a searchable database of 570 papers and reports on concrete bridge damage and repair.

Implementation and Benefits

As a result of this research, WisDOT specifications now require all exposed surfaces of prestressed concrete bridge girders to be treated with a protective coating before installation. These treatments should prevent most beam end corrosion on new bridges, reducing future maintenance costs, and may prove effective on piers and abutments as well. The coatings also provide a more cost-effective repair method that will protect beam ends from further damage longer than patching. With further development, the ConBAR software will provide valuable assistance in bridge damage assessment.

Further Research

Researchers recommend that WisDOT test the epoxy and polymer resin coatings on 10 to 15 new bridge projects in Wisconsin, as well as on three pairs of existing bridges (treating one of each pair). Tests and visual surveys should be conducted annually for at least five to 10 years.

A new WisDOT study planned for fiscal year 2006 will be performed on the same beams used in this research. The new study will evaluate promising coatings over the entire length of the beams.

This brief summarizes Project 0092-01-06, "Rehabilitation Techniques for Concrete Bridges," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nina McLawhorn, Research Administrator

Project Manager

"This research showed that coating these girders before they get out to the field is cost-effective in the long run."

–Ed Fitzgerald, P.E.
WisDOT District 5
edward.fitzgerald@dot.state.wi.us

Co-investigators:
Al Ghorbanpoor,
Amy Turnquist-Nass,
University of Wisconsin–Milwaukee